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Main findings and recommendations from Workshop on transport – renewable energy in the transport sector and planning, Technical University of Denmark, 17 - 18 March 2009

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Edited by Hans Larsen and Leif Sønderberg Petersen

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DTU CLIMATE CHANGE TECHNOLOGIES

Risø DTU
National Laboratory for Sustainable Energy

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Title: How do we convert the transport sector to renewable energy and improve the sector's interplay with the energy system? Main findings and recommendations from the Workshop on Transport – Renewable Energy in the Transport Sector and Planning, Technical University of Denmark, 17 - 18 March 2009

Division: Systems Analysis Division

As part of the DTU Climate Change Technologies Programme, DTU arranged a series of workshops and conferences on climate change technology focusing on assessment of and adaptation to climate changes as well as on mitigation of greenhouse gasses (GHG). Each workshop targeted a specific technology problem area. The Workshop on Transport took place at DTU 17 – 18 March 2009. The workshop developed and discussed recommendations for future climate change technologies. This report presents summary and recommendations from the workshop.

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Introduction

How do we reduce the CO_2 emissions from the transport sector?

The global energy scene is currently dominated by two overriding concerns that strongly affect decisions on energy development priorities. The first is security of supply and the second is climate change. IPCC's 4th Assessment Report states that if climate change is to remain in the order of 2 to 3 degrees C over the next century as anticipated then the world's CO_2 emissions must peak within the next 10 – 15 years and ultimately by the middle of the century be reduced to 50% of present level.

The transport sector is one of the most complex sectors to manage with regard to these concerns, since it on the whole is based on fossil fuels and has hitherto experienced a very fast and steady growth which has exceeded fuel efficiency gains. Hence, transport-related energy consumption and CO_2 emissions have grown significantly over the past decades, whereas it has stagnated or fallen in most other industrial sectors.

Energy consumption for transport accounts for approximately 20% of all energy used worldwide and approximately 25% in many OECD countries. In order to lower the CO_2 emissions it is an absolute necessity to introduce renewable energy in the transport sector and have the sector integrated in the energy system.

The workshop will discuss state-of-the-art and development perspectives for transport technologies, new transport fuels, new transport system concepts, energy efficiency improvements, and policy measures. Furthermore, it will summarize the present status and trends with regard to the transport sector. The ambition is to prepare the ground for an estimate of the reduction potential for the transport sector in Denmark as well as globally. The major challenges are:

- Efficiency improvements – how far can they take us?
- How much renewable energy can we introduce in the transport sector?
- How much can biofuel and electricity contribute?
- How could we integrate the transport sector in the energy system?
- Can a shift from private to public transport realistically provide a significant contribution?
- What can be done in the short term, and what are the long term solutions?

This background paper has been prepared in order to inspire and structure the discussions and target the issues for the working groups at the workshop.

The workshop will discuss what the organizing committee considers the four most important areas of transportation:

- International sea transport
- Passenger air transport and its competitors
- Private car transport
- Road based freight transport and its competitors

Transport in a changing climate

The global energy scene is currently dominated by two overriding concerns that are strongly affecting decisions about energy development priorities:

- Climate change
- Energy security

This is especially true for industrialized countries and the more rapidly developing economies, while many developing countries still do not provide widespread access to modern energy.

Energy security and greenhouse gas (GHG) emissions are interlinked, and ideally national energy policies and development programmes should address both issues. In practice, however, many national policy landscapes have been dominated by just one of these factors. In the political debate the access to energy is often seen as a potential climate problem, but most studies indicate that access to basic energy services for the world's poorest one billion people, even based on fossil resources, will make very marginal contributions to global GHG emissions. A more relevant and pressing political concern is how to limit global emissions and allow the emerging economies to continue their economic growth.

Climate change is widely recognized as the major environmental problem facing the globe and evidence is building that impacts are already being felt in the form of melting icecaps in the polar areas and increased variability of temperature, rainfall and storms in virtually all regions as well as increasing intensity and frequency of climate extremes.

The transport sector plays a crucial and growing role in world energy use and emissions of GHGs. Motorized transport relies almost 100% on oil, and in 2004 transport energy use amounted to 26% of total world energy use and the transport sector was responsible for about 23% of world energy-related GHG emissions.

Economic development and transport are closely interlinked. Development of a fast and reliable international transport system at low cost has been a precondition for the economic growth driven by globalization in terms of steadily increasing international division of labor, trade and specialization. Industrialization and growing specialization have created the need for large shipments of goods and materials over substantial distances; accelerating globalization has greatly increased these flows. Furthermore, urbanization has been extremely rapid in the past century.

Increasing economic wealth and higher travel speeds have been the core drivers in the historically strong growth in transport demand at both local and international level. Worldwide travel studies show that the average time budget for travel is roughly constant across countries as well as over time, with the speed of travel determining distances travelled yearly. As incomes have risen, travellers have shifted to faster – and more energy-intensive – forms of transport, from walking and cycling to public transport to automobiles and, for longer trips, to aircraft.

Public transport plays a crucial role in urban areas. Intercity and international travel is growing rapidly. Worldwide passenger air travel is growing 5% annually – a faster rate of growth than any other travel mode.

Worldwide the transport activity is expected to continue to grow at a rapid pace for the foreseeable future without intensified use of demand management measures. In this perspective significant reduction in transport related GHG emissions will require a radical shift away from fossil fuels. Increasing the share of renewable energy sources and integration of transport in the energy system are unavoidable elements in the necessary global strategy.

A parallel worldwide trend has been 'urban sprawl', i.e. the decentralization of cities spreading out faster than they have grown in population, with rapid growth in suburban areas and the rise of 'edge cities' in the outer suburbs. This decentralization has created both a growing demand for travel and an urban pattern that is not easily served by public transport. The result has been a rapid increase in private vehicles – not only cars but also 2-wheelers – and a declining share of transit. Further, the lower-density development and the greater distances needed to access jobs and services have seen the decline of walking and cycling as a share of total travel. A large part of the world is not yet motorized because of low incomes. However, many developing countries accounting for a very large share of the world population experience rapid economic growth which makes the prospects for a vast expansion of motorization and increase in fossil fuel use and GHG emissions very real. In addition, the gradual growth in the size, weight and power of passenger vehicles, especially in the industrialized world, has also contributed to the increase in transport energy consumption. Although the efficiency of engine and vehicle technology has improved steadily over time, much of the gains from these improvements have gone towards increased power and size at the expense of improved fuel efficiency.

Industrialization and globalization have also stimulated freight transport, which now consumes 35% of all transport energy, or 27 exajoules[1]. Freight transport is considerably more conscious of energy efficiency considerations than passenger transport because of competition driven pressure on shippers to cut costs. Rail and domestic waterways' shares of total freight movement have been declining, while road haulage's share has been increasing; air freight has been growing rapidly though it remains a small share. Transport energy use in 2030 is expected to be about 80% higher than in 2002[1]. Almost all of this additional consumption is expected to be in petroleum fuels, which is expected to remain between 93% and 96% of transport fuel use over the period. As a result, CO_2 emissions will essentially grow directly proportional to energy consumption. There will be a significant regional shift in transport energy consumption, with the emerging economies gaining significantly in share. In contrast, transport energy use in the mature market economies is projected to grow more slowly. The sectors propelling worldwide transport energy growth are primarily light-duty vehicles, freight trucks and air travel.

[1]IPCC Fourth Assessment Report, Working Group III Report "Mitigation of Climate Change", Chapter 5: Transport and its infrastructure, 2007

Civil aviation is one of the world's fastest growing transport modes. ICAO shows that scheduled aviation traffic (revenue passenger-km (RPK)) has grown at an average annual rate of 3.8% between 2001 and 2005 and is currently growing at 5.9% per year[1]. The primary energy source for civil aviation is kerosene. It is projected that by 2025 traffic will increase by a factor of 2.6 from 2002, resulting in global aviation fuel consumption increasing by a factor of 2.1. Aviation emissions were approximately 492 Mt CO_2 and 2.06 Mt NO_x in 2002 and will increase to 1029 and 3.31 Mt respectively by 2025[1].

Around 90% of global merchandise is transported by sea[1]. For many countries sea transport represents the most important mode of transport for international trade. For example, for Brazil, Chile and Peru over 95% of exports in volume terms (nearly 75% in value terms) are seaborne[1]. Economic growth and the increased integration in the world economy of countries from Far East and South East Asia are contributing to the increase of international maritime transport. Development in China is now considered to be one of the most important stimuli to growth for the tanker, chemical, bulk and container trades.

Transport can be fuelled by multiple alternative sources, e.g., liquid fuels from unconventional oil (very heavy oil, oil sands and oil shale), natural gas or coal, or biomass. Other alternatives are gaseous fuels such as natural gas or hydrogen and electricity, with both hydrogen and electricity capable of being produced from a variety of feedstock. However, these alternatives are costly compared to conventional oil products, and several – especially liquids from fossil resources – can increase GHG emissions significantly without carbon sequestration.

Longer term opportunities in the transport sector include advanced technology such as new 2nd generation biomass fuels, fuel cells running on hydrogen and battery powered electric vehicles. The most promising strategy for the near term is incremental improvements in current vehicle technologies. Advanced technologies that provide great potentials include greater use of electric drive technologies, including hybrid- electric power trains, fuel cells and battery electric vehicles.

Even with all these improved technologies and fuels, it is expected that petroleum will, at least over the next decade or so, retain its dominant share of transport energy use and that global transport GHG emissions will continue to increase. Only with large reductions in economic growth, major behavioral shifts induced by major policy intervention will transport GHG emissions decrease substantially.

The R&D challenge

Transport volumes have increased steadily over the past decades with economic development and globalisation as important drivers. Passenger and freight transport in OECD-countries has grown by 2.0% and 2.5% per year respectively[2] since 1970. Hence, it will not be unrealistic to expect transport volumes to continue to grow but at a lower rate of, say, 1.5% per year. Assuming that the transport sector will take a proportionate share of total GHG emission reductions a global GHG emission reduction by 50% in 2050 will imply that the average CO_2-intensity per passenger/ton-kilometre will have to be reduced by 93% or a factor 15, still maintaining the equity principle of equal rights to CO_2 emissions but ignoring population growth. Similarly, an 85% overall GHG emission reduction will imply lowering of the CO_2-intensity by 98%, i.e. by a factor 50(!).

[2] http://www.internationaltransportforum.org/statistics/trends/TotalFreight.xls and http://www.internationaltransportforum.org/statistics/trends/PassengerTotal.xls

Consequently, the real issue of climate change is not to improve the energy efficiency of transport but to convert transport’s energy consumption to practically *carbon-free* if dramatic increases in global temperature should be avoided in the long run.

At the same time an efficient transport system is a vital and integral part the modern, globalized society where people have a high willingness-to-pay for mobility and cheap freight transport is a precondition for the high industrial productivity enabled by worldwide marketing possibilities.

The challenge for researchers and professionals in the field of transport will be to develop technological solutions which can provide the international community with the options to achieve much lower CO_2 emissions while maintaining a very high level of mobility for goods and people.

Main findings and recommendations

Introduction

The transport sector plays a crucial and growing role in world energy use and emissions of GHGs. Motorized transport relies almost 100% on oil, and in 2004 transport energy use amounted to 26% of total world energy use and the transport sector was responsible for about 23% of world energy-related GHG emissions.

Economic development and transport are close linked. Development increases transport demand, while availability of transport stimulates development by allowing trade and economic specialization. Industrialization and growing specialization have created the need for large shipments of goods and materials over substantial distances; accelerating globalization has greatly increased these flows.

Worldwide the transport activity will continue to grow at a rapid pace for the foreseeable future. Therefore it is necessary to have the transport sector integrated in the energy system and increase the share of fuels based on sustainable energy.

Challenges and solutions

The challenge for researchers and professionals in the field of transport will be to develop technological solutions which can provide the international community with the options to achieve much lower CO_2 emissions while maintaining a very high level of mobility for goods and people. The Danish research community possesses the necessary competencies in many central areas, but the research needs to be strengthened and coordinated to obtain full impact.

The challenge for the political-administrative system is to create new frames for transport research in Denmark. Today transport research is mainly focused on planning, safety and regulation, while the research in the technological aspects in many ways is incoherent or non-existing.

Implementation issues

International sea transport

International shipping plays a very important role as approximately 90% of the world's transportation work is done by ships, which means that the CO_2 emissions from shipping accounts for 3 – 4% of the CO_2 emissions globally (Table 1 from a study by IMO in 2007). There are three important paths to reducing CO_2 emissions from intercontinental sea transport:

1. Introduction of operational measures which could include slow steaming, awareness of energy efficient operation (decision support systems for the crew), route planning including logistic planning. CO_2 reduction potential: 10 – 15%

2. Technical measures, e.g., better propellers, hull forms with less resistance, new hull painting types, introduction of wind powering, utilization of solar energy (not yet very proven) and improved diesel engine technology. CO_2 reduction potential: 10 – 15%

3. Market based measures. The two market based measures discussed in IMO in order to reduce CO_2 is a global Emission Trading Scheme (ETS) and an International Fund for Greenhouse Gas Emissions from Ships (International GHG Fund). CO_2 reduction potential: 10 – 15%

Passenger air transport and its competitors

Increased efficiency of planes

Planes have become 70% more efficient over the last 40 years, but we are nowhere near the theoretical limit. Current engines are approx. 60% efficient compared to the theoretically perfect combustion. Materials could be improved and be lighter and stronger. Aerodynamic improvements could make wings more efficient and reduce the drag. Hydraulics could be replaced by electric devices. Energy harvesting technologies like piezoelectric, thermoelectric and solar could be applied to a much higher extent. Fuel cells could produce the electricity needed on board.

Lower flight speed

Lower flight speed is an efficient measure to reduce CO_2 emissions from aviation. Flying at significantly lower speeds implies optimizing designs and air traffic management (ATM). Another issue is if passengers are willing to accept longer flight times.

Renewable energy in planes

Types of alternative fuels:

1. Synthetic fuels like gas, coal and other hydrocarbon resources
2. Fuels like ethanol, methane and liquid hydrogen
3. Biofuels like soy beans, algae, jatropha, halophytes and camelina

In the long term many possibilities are being researched, e.g., fuel cells, hydrogen and different kinds of solar energy.

Optimizing the overall ATM and flight control system

ATM is the first step against reduced CO_2 emissions, followed by next generation planes, the ACARE goals for 2020, and finally alternative fuels.

The IPCC studies showed that improvements of 2 to 18% are possible of which 6-12% are ATM related.

Policy instruments in aviation

There is a need for global consensus and global goals if the CO_2 emissions from passenger air transport should be reduced.

The industry has made remarkable progress with only market forces.

A policy to reduce emissions should include technology/standards, operational and market based measures, and alternative fuels.

High speed trains on short haul routes

Short haul (travel time less than 800 kilometers/3 hrs) can be delivered more efficient with other means of transport like high speed trains, and it is important to utilize the complimentary effects of different means of transport. The cooperation between train and plane could be more efficient by common check in systems etc.

Private car transport

The demand for private car transport will not decrease in the future – but rather rise steeply, in the light of increasing welfare, especially in the major fast growing countries in Asia and – potentially - in Africa. Hence, the only solution appears to be new technologies for traction which can efficiently utilize non-fossil fuels.

In the short term efficiency improvements have a strong role to play by decreasing the fuel consumption and thereby the CO_2 emissions.

Flexibility in the future sustainable energy system is another driver for alternative fuels for transportation. A solution is electrical vehicles based on batteries charged from sustainable sources. Furthermore, electrical vehicles are highly energy efficient. The limited availability of renewable sources puts a strong focus on energy efficiency, which a quick introduction of battery cars can contribute to. In the long term fuel cells and hydrogen might become an option in parallel with electric vehicles.

Road user charge is very likely to be introduced in many European countries in the coming years. Not only due to the potential as a means of reducing CO_2 emissions, but also due to the potential as a traffic management scheme for reducing congestion and local detrimental effects of transport

Diversity of supply is important to avoid strong economic and technical monopolies. Also, it is a stabilizing factor if several sources might contribute to fuel production so that vital activities would not necessarily be hampered by break-down of one supply chain.

Road based freight transport and its competitors

Freight transport is mostly operating in urban areas (within cities) and interurban (between cities and regions). The diesel engine has until now been the most efficient propulsion system for road freight. Gas is an alternative fuel with some potential in urban and to some extent interurban freight transport. Electric driven trucks are with the present battery technology not an option for large trucks, but may have a potential in urban distribution with small vans.

There are several initiatives that can improve fuel efficiency also in the road freight sector, e.g., training drivers in energy-efficient driving techniques, allowing larger vehicles, and reducing average driving speed are three initiatives. Furthermore, the use of taxes and charges holds potential in the short run. This instrument will increase focus on delivering better and smarter transport solutions with lower energy consumption etc.

The potential for rail freight transport must be seen in a larger perspective.

Welcome

Niels Axel Nielsen, Director, Public Sector Consultancy, Technical University of Denmark
Chairman: Hans Larsen, Head of Systems Analysis Divison, Risø DTU, Denmark

Ladies and gentlemen.

It is a great pleasure for me on behalf of DTU to welcome such a large audience from industry, from government agencies and public management, and from universities and science to our workshop on renewable energy in the transport sector and planning. In particular I welcome our Minister of Transport, Lars Barfoed. It is a privilege that you have accepted to give the opening speech and share your views with us this morning.

In particular I welcome the participants who have accepted to give keynote presentation and to contribute to the working groups later today. I am confident that these talks and hopefully many interventions from the audience will give us two useful days.

The thorough work by the IPCC panel point to the need to reduce greenhouse gasses and also other subsequent analyses, for example the Stern report shows that if we take swift and effective action now we can accommodate the costs.

The challenge is actually not only to reduce GHG emissions, but we need to reduce GHG emissions and at the same time secure energy supply to sustain a population growth form 6 to 9 billions and to eradicate poverty. And on a local and regional scale we also need energy supply security for geopolitical reasons and independence.

We need food security, it requires energy and land use. And all this should be done in a world with limited resources of water and minerals.

This requires widespread technology development and deployment.

DTU's mission is to develop and create values using our scientific resources and manpower to benefit growth and welfare in society. The government decided on the structural reform of Danish universities and research institutes in 2007 and DTU has today in the order of 1000 scientists and a staff of 2000 who work with topics directly relevant for the challenge just stated. We at DTU are committed to do our best to contribute to meet this challenge.

Therefore DTU has implemented a cross-departmental initiative called DTU Climate Change Technologies. This term is chosen because technology will be a crucial element in solving the problem.

DTU Climate Change Technologies have four pillars

The first pillar is to accelerate the development and deployment of technology; we need urgent action and there should be equal weight on both development and deployment.

The second pillar is to work efficiently with other world class universities.

Thirdly we will enhance our capacity to give advice to public authorities and private companies, they need factual, up to date and holistic advice based on tools which take into account the complexity of the problem. Finally we will make sure our graduate program is in line with future requirements.

To kickstart the first pillar we arrange workshops in 2008 and 2009. We invite participants from the private sector, from public authorities and from research. It is a key driver for development that there is strong interplay between these three parties. The scientist should develop innovative technology and the industry should make it commercially available and competitive. Only in this way we can ensure a strong market penetration. Public authorities should ensure that the framework conditions, taxes and subsidies are promoting the right kind of technology until it is competitive.

This is the program for 2009. We cover all areas where we at DTU have forefront scientific capacity and we cover key energy technology as well as end user and sector aspects.

So why were we sure that we needed a workshop on transport – I believe the answers are apparent to everyone in this room:

1. It takes up a fourth of the energy use
2. It is closely linked to growth
3. It is technology intensive and we cannot pick the winner or winners yet
4. The winner is difficult to identify maybe because there is a strong interplay with the energy system
5. We need the right track because there are large up-front investments
6. There is a strong public-private interaction - another of our key focus areas for the workshop series
7. And finally it is a core field for several departments at DTU

With these words I have briefly described our initiative.

I now pass the floor to the minister of transport Lars Barfoed. We are privileged that you will share your views with us this morning. A large infrastructure investment plan for transport has just been completed by the Minister and Parliament and transport is in focus when we talk climate mitigation and adaptation in Denmark. So we look very much forward to your talk.

Opening speech

Lars Barfoed, Minister for Transport, Denmark

Thanks for the opportunity to give a speech at this important workshop and I am glad to see so many international participants.

The workshop raises the important question: How do we convert the transport sector to renewable energy and improve the sector's interplay with the energy system? It is a difficult question to answer, and it is important to discuss in a forum like this.

The objective of the Danish Government is to reduce CO_2 and maintain mobility. Transport is a quality of life, an essential link between families and businesses. Mobility is a basis for welfare.

We are all dependent on a well-functioning transport system, but we use 25% of our energy consumption to transport and it will grow. This trend the Government will reverse. The Government will turn the transportation policies in the green direction with a world-class infrastructure that should be developed continuously.

In January 2009 the Government adopted a green transport policy to promote mobility and reduce CO_2 emissions. The idea is to make Denmark independent of fossil fuels and support the use of greener fuels.

Public transport will be upgraded and made better. There must be a reorientation of taxes in a sustainable direction. There must be emphasis on new technologies.

The plan will be gradually put into service during the next ten to fifteen years.

The Government will invest massively in public transport, including high speed trains and departure on time. The intention is to get more people to use public rather than the car. Should it succeed, public transport must have a high quality.

Fees must be restructured to make it attractive to buy a sustainable car and use it in a sustainable manner. The car is a key means of transport throughout the world and will be central in the future.

Investments will be made in research and development of new technologies for electric vehicles, since the electric and hybrid cars are playing important roles in the future. Our vision is to produce efficient electric vehicles in the near future. They should be exploited extensively together with plug-in hybrid cars in the Danish transport system.

The vision is to turn Denmark into a green test laboratory for transport. The idea is to make Denmark an attractive country for testing of new technologies such as electricity and hybrid.

Until then, we will focus on actions that can lead to rapid CO_2 reductions.

Research into the transport sector must be strengthened through the Center for Green Transportation. The center will work with a number of concrete initiatives to help reduce CO_2 emissions.

DTU's workshop on transportation is an important contribution to the development of transportation technology, so I thank those who organized the workshop as well as the participants, and I look forward to the recommendations of the workshop. We want to study these in depth in the Transport Ministry.

The taxes on buying a car must be lowered and replaced with a charge to ride in it. Electric cars are free of tax until 2012 and we will investigate how the charge could be in the future, including maintaining a low tax on electric cars or maybe none at all, but on a long term scale it is fair that there is a low tax after 2012.

Presentation of discussion paper for the workshop

By Niels Buus Kristensen, Director, DTU Transport

The challenge of climate change in the transport sector

Global warming is a fact and there is strong evidence that the global anthropogenic emissions are a significant factor.

Global distribution of GHG-emissions shows that the average emission in the Annex I countries – the rich countries - is 16.1 t CO_2-eq/cap, while it is 4.2 t CO_2-eq/cap in the non-Annex I countries. Most people believe that it will be difficult to make a long-term solution that does not provide all people in the world with the right to emit the same amount of CO_2 as we do in the richest part of the world. Therefore, the right of CO_2 emissions should be divided equally among all people on Earth. From this global view, the rich part of the world should more than halve its CO_2 emissions if we are to reduce CO_2 emissions by 50% in 2050. This is a very big challenge.

Historically, economic growth and transport have been closely linked, which is a very significant barrier for reducing GHG-emissions from transport.

It is likely that the transport sector will be growing in the future. It has grown by 2% per year over many years, so even a conservative estimate of the future is 1.5% annual growth. If the transport sector must take its share of the burden, the CO_2 emissions per ton transported one kilometer should go down to 7% if we are to reduce CO_2 emissions by 50%. This is a reduction by a factor of 15. By then a car that is currently running 12-15 km per liter needs to run 200 km per liter.

Economic progress will give rise to continued strong global transport growth. The challenge is immense. How can we accomplish the mission? The majority of the transport sector has to be carbon-free in the long term! The biggest challenges are within these four sectors: Aviation, intercontinental sea transport, road based freight transport and private car transport.

If we take a look into the future there are two separate aspects:

I: What are the potential technological solutions in the long run? There are the solutions known or close to market, however, while other solutions require heavy R&D or are unknown.

II: Which policy measures should be adopted in the short run to realize the optimal solutions? It is important to ensure cost-minimizing solutions and avoid that short-termed efforts become dead ends for long-termed solutions.

The future for the transport sector – Energy technology perspectives

by Pieter Boot, Director, Directorate of Sustainable Energy Policy and Technology, IEA

IEA Energy Technology Perspectives 2008 analyses a low CO_2 world: what it looks like and how to get there. It is a study primarily about the role of technology with baseline and low-CO_2 scenarios to 2050 together with short and medium term technology policy needs.

The scenario analysis uses a baseline from WEO2007 Reference Scenario and anticipates global stabilization by 2050 (ACT – up to $50/tonne) as well as global 50% reduction by 2050 (BLUE – up to $200/tonne). It was fed into the Hokkaido G8 plan of action.

The baseline scenario is entirely unsustainable as the need for oil will increase dramatically together with increased use of liquid fuel. Almost the entire growth comes from the transport sector. Oil will run out in 2050. After that coal will be converted to liquid fuel, which will cause CO_2 emissions to rise. There is a need for a 50% reduction at that time, and we have created the blue scenario to fulfill this. In this scenario the transport sector really must contribute to CO_2 reductions.

The blue scenario represents a radical change in technology, but we are unsure on which technologies will win, therefore we operate with four sub-scenarios in blue, and biofuel plays a role in all of them.

The blue scenario includes measures costing up to $200-500; reduction of global CO_2 to below 2005 levels with downward trend. In the transport scenarios there are the following assumptions:

1. BLUE Map – mix of biofuels, fuel cell vehicles (FCVs), and electric vehicles (EVs) for cars and light trucks in 2050

2. BLUE Conservative – no FCVs or EVs (only plug-ins)

3. BLUE FCV Success – FCVs dominate by 2050

4. BLUE EV Success – EVs dominate by 2050

In the ETP BLUE for the Non-LDV (Light-Duty Vehicles) Transport Modes the following results were estimated:

- Air: 15% efficiency improvement over baseline (30% in baseline) by 2050 and 30% BTL fuel by 2050

- Shipping: 30% efficiency improvement by 2050 and 30% biofuels by 2050

- Trucks, buses: 30-50% efficiency improvement by 2050 with same biofuels share as for LDVs and medium trucks with 50% fuel cell/EV by 2050

A modal shift is assumed: Strong transit development in developing cities, intensive development of high-speed rail, shift of ¼ of long-distance freight from truck to rail, and overall perhaps a 10-15% reduction in car, truck and air travel in 2050.

In ETP blue efficiency gains are important. We must always begin with improved efficiency, because everything else costs more.

It is possible to improve vehicle efficiency by 50% in 2050. Special efforts are required in developing countries like India and China, where the number of private cars are growing strongly.

Plug-in hybrids can dominate in 2050.

Hydrogen fuel cell cars will emerge on the market in 2025.

Biofuels could reach 12% in 2030.

Plug-in hybrids will be the transition to electric cars.

For electric cars the range and battery cost is crucial, battery cost should drop to 1/3 of what it is now. Electric cars must be able to run over 150 km and should be loadable both night and day.

It requires an active role of politicians to achieve this, and there is a need for a set of roadmaps and coordination to achieve this.

In BLUE Map scenario biomass use will increase from current 1000 Mtoe (including traditional) to around 3600 Mtoe (150 EJ) per year in 2050. Half of the consumption must come from crops grown for energy purposes, corresponding to 4% of the global agricultural area; can that be done without harming food production? In 2050 the major part will be 2nd generation biofuels such as cellulosic ethanol and biomass-to-liquids diesel. These should be very low GHG fuels but this will depend heavily on net global agricultural impacts, including land use change. The main demand growth for biofuels after 2020 is expected to come from heavy duty vehicles (trucks, ships, aircrafts) and thus be for distillate and bunker type fuels.

The economical perspectives

by Philippe Crist, Joint Transport Research Centre of the OECD and the International Transport Forum, France

The transport sector as a whole accounts for approximately 13% of overall GHG emissions and 24% of CO_2 emissions from fossil fuel combustion in 2006. On a well-to-wheel basis, the IEA estimates that transport accounts for nearly 27% of total CO_2 emissions from fossil fuel combustion.

Transport is the second largest CO_2-emitting sector after electricity production. In OECD and ITF countries, the shares of transport CO_2 emissions are 30% and 26% respectively in 2006 – although some countries display very different shares.

Road transport emissions account for two thirds of transport CO_2 emissions. Much of the growth in emissions has been in step with GDP growth and the resulting increase in numbers of vehicles and international travel. The rate of transport emissions growth has accelerated globally from an annual average growth of 2.11% from 1990-2000 to an annual average growth rate of 2.26% from 2000-2006. This has largely been driven by non-OECD countries as OECD transport CO_2 emission growth rates have fallen in the past 6 years (1.16%) as compared to the period 1990-2000 (2.07%)

In Germany, transport CO_2 emissions have been declining since the late 1990s due to: i) vehicle fuel economy improvements; ii) biofuel tax exemption and quota system; iii) increased fuel taxes on conventional fuels; iv) road pricing of heavy duty vehicles; v) differentiated vehicle excise taxes linked to engine displacement; and vi) new vehicle labelling.

France has been able to stabilize the emissions due to: i) improved vehicle fleet efficiency; ii) reduced travel speeds; and iii) stabilized travel volume.

In Japan, the emissions have also decreased since 2001 even as the economy grew. This is due to: i) improved load factors in road freight transport; ii) improved vehicle fuel economy triggered by increasingly stringent standards; iii) an increased share of fuel efficient micro-cars and the greater number of hybrid drivetrains; and iv) reduced traffic congestion.

The drivers for change in LDV (Light-Duty Vehicles) CO_2 intensity are:

- Long-term fossil fuel prices driven by scarcity and growth in BRICS (Brazil, Russia, India and China)
- Carbon constraints stemming from international and national CC rules
- Energy security is imperative – but could lead to more CO_2

The current system delivers great benefits but a high carbon output and significant potential energy insecurity. Other impacts of transport include safety, congestion, noise and air pollution. These are all more or less captured in current EU pricing structures but there is a sense that our current transport system is not sustainable.

Economist Herb Stein said – “Things that cannot go on forever, don’t”.

This is where we are heading in transport and the fundamental challenge is how to anticipate, accompany and facilitate change to a system that continues to deliver societal benefits with less adverse impacts.

6 key messages

1. Many technology-related GHG reduction measures in the transport sector are relatively low cost or may even save money over time, but the absolute contribution of low-cost CO_2 abatement from transport will most likely be less than that of other sectors. While net average social costs may be low, capital costs are likely to be high in the transport sector compared to low-abatement cost measures in other sectors.
2. The potential for catastrophic outcomes and uncertainty regarding the impacts of GHG reduction implies that standard cost-benefit assessments may not be suitable to evaluate GHG reduction policies. Assessing measures according to their cost effectiveness in contributing to GHG mitigation objectives may be a better guide policy.
3. Fuel efficiency standards are essential to encourage consumers to make fuel economy investments. Long term fuel economy standards would create the stability car manufacturers need to invest in new technologies.
4. Well designed CO_2-based differentiated vehicle taxation or feebate schemes hold great potential to stimulate both supply and demand for fuel efficient vehicles.
5. Fuel carbon standards and transparent biofuel sustainability criteria are essential in ensuring that shifting from oil to alternative fuel sources results in less, not more, lifecycle CO_2 emissions.
6. Demand management is also an important strategy. Mobility management initiatives, land-use planning and promotion of high quality public transport can all help to reduce GHG emissions and at the same time deliver synergies and co-benefits related to congestion mitigation as well as air pollution and safety improvements.

Core road transport measures

- Cost effective fuel efficient technology
    - LDV fuel efficiency / CO_2 regulatory standards (incl. non-test components)
    - Differentiated vehicle taxes
    - Fuel and/or CO_2 tax (targets activity, efficiency and fuel carbon intensity)
- Demand management
    - Parking and road pricing (targets activity/volume)
    - Public transport investment and spatial planning

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Renewable energy for transport

by Robert Schock, World Energy Council, UK

Transport is a vexing problem. Vexing means irritating, annoying and not much one can do about it:

- Transport already uses 1/4th the world's energy
- 2 billion people want access to modern energy systems
- Governments are working hard to get modern energy to people
- A mobile pollution system composed of very small parts
- We are locked into ICEs (Internal Combustion Engines) running on petroleum
- More than double the number of vehicles by 2030?
- Air transport is growing fastest
- 1/4th of carbon from freight

Key concepts are that transportation respects Cost and Convenience (Comfort) and is carbon free. That points on electric vehicles or hydrogen as the best choices and means that the electricity should be produced from sustainable energy sources like wind, solar, nuclear and bio.

The prospects for fuel cell electric vehicles are that if costs develop as in optimistic projections, FCEVs (Fuel Cell Electric Vehicles) could approach ICEs' (Internal Combustion Engines) cost position after 2020. Availability of hydrogen infrastructure is not an immediate problem (electric/gas grids). Many barriers to hydrogen and fuel cell electric vehicles (FCEVs) must be overcome.

The prospects for battery electric vehicles are that if range and cost develop as in optimistic projections, full spec BEVs (Battery Electric Vehicles) could be viable after 2030. Availability of charging infrastructure is not an immediate barrier.

Energy analysis results for passenger vehicles show that diesels (and hybrids) provide a few percent energy reduction at high penetrations. FCEV can bring greater reduction but at higher cost, and advanced biofuels bring very high reductions, but sustainability must be ensured, that is for example production from algae.

The full report is available at www.worldenergy.org/publications/809.asp

Policy actions to ensure a smooth & rapid transition

1. Technologists and politicians need to work together to make sure that we understand what are short-term visions and what are longer-term visions, as the politicians tend to go for the short-term solutions
2. Increase funding for RDD&D and integrate it internationally
    a. on advanced energy-efficient vehicles
    b. on no- and low-carbon fuels
    c. new mobility services
3. Improve the regulations for fuel economy and requirements for ZEVs and LEVs
4. Establish a price floor for fossil-fuels
5. Set a realistic price for carbon (COP15)

    a. allow mechanisms suited to national situations

6. Create incentives for electricity and hydrogen in the transport sector
7. Educate people about basic principals of energy forms and uses
8. Stop killing siblings!

Technology innovation for environmental shipping

by Bo Cerup Simonsen, Vice President, A.P. Moeller - Maersk, Denmark

On the mind of a ship owner is:

- Markets have dropped
- Record delivery of ships
- Plenty of spare capacity at anchor
- Climate change?

The standpoint of A.P. Moeller – Maersk is that we recognize that carrying out our business in a safe and environmentally sound manner is a prerequisite to our success and our future.

Strategic level of environmental performance

At which the level of sustainability should Maersk be? High or low on the scale; from the lowest with focus only on business strategy, to the other end of the scale with eco advantage, where environmental shipping is in focus? We strive to be at the higher end.

To achieve this we are working to implement new regulations together with organizations such as the IMO to ensure that new regulations fit into practice. We are working on new technologies to support technological development. We have a technical group to design new ships and upgrade the fleet.

The main focus is on fuel efficiency.

When we order a new ship it takes 2-3 years before it is delivered and it is active in 20 years. Our customers will demand sustainability, the regulations will be tougher, energy costs will grow, new technologies come into play, and employees and shareholders will demand awareness. A green ship may be a reality in 2030, but we are moving slowly towards the goal. We publish all environmental data on the Internet, including how much fuel we burn.

We are already seeing how customers want us to stick to a green strategy, for example the Tesco supermarket group has CO_2 labels on their products.

New regulations through the IMO are important because they must be the same everywhere. If they are not the production facilities move to where it is cheapest. We want global measures and they should be target-based and not detailed. That will leave us the room to find the best solutions for the individual ship line.

Speed reduction is an important issue, because lower speed means falling capacity, while increased speed means higher capacity.

What happens if we retain the capacity but reduce the speed to for example 8 knots, then we will need 26 ships, whereas we only need 11 ships cruising with 17 knots. Lower speed gives large gains in fuel savings and lower CO_2 emissions. That means that the total cost decreases, and CO_2 emissions decrease 40%. The optimum speed is 50% of max, with approx. 10% engine load.

The design of ships can be made more efficient. Today's ships are diverse even though they have the same size, this is because we did not have a focus on efficiency.

As ship-owner, we are very conscious of stimulating the development of more efficient ships. There are plenty of development opportunities in the design of antifouling, hull shape, waste heat and propeller system. A low hanging fruit is sleeker antifouling. Then hull shape. In this way a standard ship can be turned into a green ship.

A new design for the bulb can save 8% fuel, and it costs nothing to do. So there is much to do on the technology side, including new propulsion systems and machinery.

All our new ships at Maersk are state of the art

The scrapping of ships should be made more environmentally friendly and sustainable by recycling. A group in Rotterdam is working to recycle ships and it is only done at yards fulfilling certain requirements.

We have looked at kite systems, but they do not work at 26 knots, but wind power can make a contribution.

We look at nuclear, natural gas and biofuel, but we have no clear idea about the winner.

We have observed that we will lose customers if we reduce the speed. It is worth to remember that a container ship has a very mixed cargo, among which some items can keep long, while others keep very short.

An overview of technology innovation for environmental shipping:

- We can afford more environmental shipping
- Need international, goal based regulations
- True performance metrics and transparency
- Redefine industry collaboration to optimize totality
- Mobilize customer power in supply chains
- Challenge conventions: operations, technology and ship designs
- Analysis, benchmarking, engineering and environmental shipping are good business!

International passenger air transport

by Jan Närlinge, President, Boeing Northern Europe, Vice President, Boeing International

This workshop deals with one of the biggest challenges for us; aviation is needed to get the world to work, however, we must find a way to do it without CO_2 emissions. Aviation is an important part of globalization in all sectors.

Our operations and services must become more sustainable, we can do more and we can do it faster. There is much misinformation on aviation, including the aviation's impact.

We will use the Toyota principle which is removing all redundant. New planes must be as lightweight as possible, so that it takes lesser fuel to operate them. Boeing's lean programme is a systematic prevention of waste and sustained continuous improvements in our design and manufacturing processes. Boeing's lean programme has saved 37% in energy use and 27% water.

Aviation's contribution to the global community and the global economy will from 2006 to 2026 increase from 1.5 teradollars to 3.9 teradollars.

Today air traffic is efficient compared to SUV, trains and private cars with a SUV using 7.0 litres pr. 100 passenger kilometers, while a Boeing 787 consumes 2.3 – 3.6 litres pr. 100 passenger km.

Air transport contributes today with 2% of the total CO_2 emissions from transport, and 3% in 2030 if nothing is changed. But we are part of it, and we take our responsibility

The principles that guide Boeing's actions are:

- Technology unlocks the future
- CO_2 and fuel are the priority
- System efficiency is essential
- A global approach involves and benefits everyone

New technology such as 787 dream liner will lead to:

- 20% reduction in fuel and CO_2
- 28% below 2008 industry limits for NOx
- 60% smaller noise footprint

The low-hanging fruit is a move from fossil to biofuel. But it must not compete with food or deforestation. We are actively pursuing sustainable biofuels:

- Evaluating potential feedstock and processing methods
- Working with customers to develop viable supply models

- Collaborating with airlines, engine companies and fuel suppliers to demonstrate and certify sustainable biofuels
- In dialogue with policy makers and organizations to advance the socio-economic and environmental benefits of sustainable biofuels

Air space modernization will provide significant near-term benefits. To day most air traffic systems are serving increased demand with outmoded technologies. System congestion and delays, waste fuel and increased emissions.

A next-generation air traffic system will enable more direct/efficient routing and taxi routes and eliminate wasteful hold-times in the air. Modernization of the airspace is needed, we wait too much in the airspace at the airport, therefore is the next generation air traffic control system important. According to IPCC ATM enhancements could improve fuel efficiency and CO_2 emissions by up to 12%. And according to IATA cutting flight times by a minute per flight on a global basis would save 4.8 million tons of CO_2 every year.

Boeing and Airbus signed an agreement to work together to ensure global interoperability in air traffic management. The goal is to accelerate improvements to the world's air transportation management system in order to increase efficiency and eliminate traffic congestion.

As a leader in the industry, Boeing has an obligation to be active in proposing solutions to our environmental challenges. We continue to invest significant resources towards advancing technologies that will enable the next great leap forward.

Passenger transport in private cars on short and medium distances

by Nils-Olof Nylund, Professor, VTT Technical Research Centre of Finland

Challenges in transport

- Energy related challenges (technological aspect):
    - Regulated emissions and air quality
    - Primarily particulates and nitrogen oxides will be controlled on developed markets
    - Greenhouse gas emissions
    - Energy efficiency
    - Oil dependency and sufficiency of energy
- ”Political” challenges:
    - Increase in transport work and congestion
    - Dispersion of community structures
    - Modal shift in transport
    - Traffic accidents

The environmental impact is the product of transport work (e.g. in kilometres) times specific emissions (e.g. grams of CO_2 /km or milligrams of PM/km). Technical improvements can cut specific emissions and energy consumption, e.g. the International Energy Agency (IEA) and International Transport Forum (ITF) are concerned about the increase in world vehicle numbers and transport work. If the number of passenger cars multiplies by a factor of three by 2050, specific emissions should be cut by two thirds to stabilize emissions and even more to reduce emissions!

Current status of vehicles

The current passenger car is:

- reliable
- comfortable
- relatively safe
- environmentally friendly as regards regulated emissions
- in most cases a ”high-performance” vehicle

What should be improved?

- fuel efficiency
- the ability to use renewable or CO_2-neutral energy

Traditionally heavy-duty vehicles have been fuel efficient but dirty, but latest with the oncoming Euro VI emission regulations this situation will change.

CO_2 emissions have fallen when we see new models at motor shows. A 1st generation diesel Golf had a CO_2 emission on 169 g/km, the newest Blue Motion version of the Golf emits 99 g/km, but the weight has doubled, which takes some of the gain. What would have happened if the technical potential would have been used for fuel efficiency only (keeping performance and weight constant)?

Factors affecting CO_2 emissions

Vehicle use:

- Load
- Mileage
- Traffic fluidity
- Information system
- Driving behavior
- Environmental conditions

Technology:

- Fuel carbon intensity
- Driving resistance
  - weight
  - aerodynamic drag
  - rolling res.
- Driveline characteristics
  - manual/automatic
  - hybrid
- Power plant characteristics

In the period from 2000 until 2006 Japan has succeeded in cutting CO_2 emissions from transport with 42% improvements in vehicle technology, 56 % in traffic control and 2 % in fuel technology.

EU has set unambiguous goals for 2020 (decided in December 2008):

- 10% renewable energy in transport (biofuels + renewable electricity)
- binding CO_2 limits for passenger cars, 130/120 g/km gradually 2012....2015
  and 95 g in 2020 (preliminary)
- reduction of fuel carbon intensity (6% binding + 4%)
- new fuel specification allowing 10% ethanol in petrol and 7% FAME (fatty acid methyl esters) in diesel

The International Energy Agency (IEA) has made projections into 2030 and 2050 showing the possibility for substantial reductions.

How to sustain transportation without oil?

IEA Energy Technology Perspectives 2008 (ETP 2008) shows pathways to sustained economic growth based on clean and affordable energy technology:

- Given a projected 3-fold rise in travel demand to 2050, average emissions per kilometre must be cut by two thirds just to stay even; cuts of 75% or greater are needed for a substantial emissions reduction

- While most attention is focused on light duty vehicles, the other half of the demand (trucks, airplanes and ships) may pose an even greater challenge because of the shortage of viable alternatives to oil (such as CO_2-free electricity or hydrogen).
- The largest demand could be for biomass-to-liquids (BTL) fuel for trucks, airplanes and ships
- One medium- to long-term solution for all transport modes, it must, however, be to improve fuel efficiency
- Plug-in hybrids and electric vehicles have emerged as an important option, bolstered by the rapid progress in battery technology
- Plug-in hybrids could be introduced gradually as infrastructure develops
- However, important technological challenges must be overcome before this will become a mass production option
- Overall, through a combination of strong efficiency gains, partial electrification of some transport modes and significant use of 2nd generation biofuels, a reduction of about two thirds in transport GHGs in tailpipe emissions can be achieved relative to baseline 2050

The 50 by 50 initiative

The Federation Internationale de l'Automobile (FIA) Foundation in UK has together with IEA, International Transport Forum (OECD) and UN initiated the Global Fuel Economy Initiative 50 by 50, which was launched in Geneva in March 2009. The goal is to make the world car fleet 50% more fuel efficient by 2050.

Technical tool box

The technological tools for reduced CO_2 emissions from private cars are:

- Improved engine technologies
- Reduced need for power
- Hybridization
- Electrification
- Fuel cell technology
- Biofuels

There have been a row of "hypes", starting with fuel cells, followed by biofuels and now electric vehicles. A hype-wave is always followed by reality: not one single technology will solve all problems!

Electric vehicles

- Battery electric vehicles
    - high efficiency in the end-use part (60% lower energy consumption compared with ICE vehicles)
    - the CO_2 balance depends on how the electricity is produced
    - batteries are still problematic (energy density/weight, cost, durability...)
    - emphasis on lithium batteries
    - several manufacturers have announced small EVs for 2010
    - target price in Japan 30 000 €
- Tethered vehicles do not suffer from energy storage problems

- trolley buses are surprisingly common in Europe (e.g., Italy, France, Switzerland, East-European countries)

The Japanese projections for EVs are that an EV that performs 500 kilometers on a single charge will be ready in 2030.

EV calculations and data

- Energy consumption ~ 0,15 kWh/km (small car)
- CO_2 emissions from electricity production
  - EU average 405 g/kWh
  - Finnish average 170 g/kWh
  - Nord Pool 100 g/kWh
  - grid losses 7%
- WTW CO_2 emission of a small EV 16...65 g/km
- Current price of lithium batteries 1000 €/kWh
- Toyota FT EV battery pack 11 kWh
  - range 80 km
  - cost of battery pack 11,000 €!
- Weight of lithium battery 1 kg/100 Wh
  - the battery pack of a small BEV or a PHEV weights some 150 kg
  - the pack of a family size car (30 kWh) some 300 kg
- Charging power 3,5 kW (220 V, 16 A)
  - one hour of charging gives some 15 km
  - with petrol "charging power" ~ 10 MW!

Plug-in hybrids

- Hot topic of today; this technology could make a significant contribution to the passenger car market in the future
- Increased size of battery package relative to autonomous hybrids and the possibility to charge from the grid
- Electric range some 50 km; the ICE secures extended range and therefore the battery pack is not as critical as in the case of BEVs
- No major infrastructure modifications needed in the introductory phase
- Conversions of Toyota Prius
  - several commercial battery packs available
- Several auto manufacturers have PHEV projects, commercialization in 2010 – 2011
  - GM Volt/Opel Ampera
  - Toyota
  - Volkswagen
  - Fisker Karma

Alternative pathways

- Electric
  - multiple energy sources
  - need for new vehicles
  - electric vehicles cannot be mandated, need for incentives
  - vehicle energy consumption 0.15 kWh/km
  - electric feed 0.16 kWh/km
  - WTW CO_2 emissions
    - 65 g/km (EU mix)
    - 16 g/km (Nord Pool)

- Biofuels
  - the best biofuel options are compatible with existing and new vehicles
  - biofuels can be mandated
  - need massive investments on the production side
  - sufficiency of feedstock?
  - VW Polo BlueMotion 96 g/kWh
    (tailpipe on diesel)
  - WTW CO_2 emissions
    - diesel 115 g/kWh (tailpipe * 1.2)
    - best biofuels 12 g/km
  - (BTL from waste wood -95% reduction in WTW GHG emissions, BTL from farmed wood -93% according to the RES Directive)

Summary

- Progress in automotive technology has been significant over the last 15 years
- The reduction of regulated emissions has driven the process, now the focus for passenger cars is moving towards energy efficiency
- EU has already set the stage for 2020
- Electrification of both auxiliaries and driveline under way
  - battery cost and performance still limit the break-through of EVs
- By the year 2050 there will be major changes in the whole transportation system
- All measures from technical measures and renewable energy to traffic control measures are needed to adapt transportation to sustainability
- The best biofuels options can be as CO_2 efficient as the electric pathway
- Individual mobility is highly valued, we will probably still use passenger cars after 2050

Transport, climate and energy perspectives

by Martin Lidegaard, Chairman, Concito

We should not focus on the long term solutions, if we look at the IPCC recommendations we need dramatic reduction within the next 10 years. Therefore it is important to do our best on the short term, but it should not prevent us from finding solutions for the long term. We need to halve the CO_2 emissions in the western world in 2020 since the emissions will continue their growth in developing countries like India, China and others.

How to reduce CO_2 from the transport sector? There are three ways to CO_2 reductions:

- Better efficiency
- Gas
- Biofuels

The demand for energy will not decrease if we want to fight poverty. This calls for continuing the globalization and the driver for this is transport of goods.

Better efficiency can be obtained by several means:

- Technical improvements (engine, size)
- Other transport forms (rail, sea)
- Lower speed
- Better distribution

This implies a potential of 20%-30% CO_2 reduction. The necessary measures are regulation, taxation and infrastructure.

By switching to gas a 14% reduction in CO_2 emissions from transport is obtained. The necessary measures are regulation, taxation and infrastructure.

When it comes to biofuels 1st generation have limited CO_2 effect, 2nd generation have problematic indirect effects, and finally it is a volume question. Biomass should be burned in power plants and not in the transport sector.

The conclusions are:

- Better efficiency: cheap and sustainable
- Gas: rather cheap, rather sustainable
- Biofuels: expensive and not sustainable

Report from working group 1: International sea transport

Chair: Christian Breinholt, Director, Danish Maritime Authority, Denmark

Referee: Hans Otto Kristensen, Senior Scientist, DTU Mechanical Engineering

Introduction

International shipping plays a very important role as approximately 90% of the world's transportation work is done by ships, which means that the CO_2 emissions from shipping accounts for 3 – 4% of the CO_2 emissions globally (Table 1 from a study by IMO in 2007).

Table 1. Consensus estimate 2007 CO_2 emissions [million tonnes CO_2]

	Low bound	Consensus estimate	High bound	Consensus estimate % Global CO_2 emissions
Total ship emissions[1]	854	**1019**	1224	3.3
International shipping[2]	685	**843**	1039	2.7

[1]Activity based estimate including domestic shipping and fishing, but excluding military vessels

[2]Calculated by subtracting domestic emissions estimated from fuel statistics from the activity based total excluding fishing vessels

In the last two years there has been an intensive work in the International Maritime Organisation (IMO) on establishing new regulations for CO_2 emissions from ships, which means that ship energy efficiency is now being connected to the future legislation. IMO is contemplating technical, operational and market based reduction measures, and one of the technical measures is the development of a so-called Energy Efficiency Design Index for New Ships (EEDI). The index would mandate a minimum efficiency for new ships and is in a way comparable to the eco-labelling of cars (CO_2 emissions/km).

Efficiency is in this context the ratio between the environmental cost, which is the contribution to global warming through emission of CO_2 from combustion of fossil fuel, and the benefit for society, which is the performed transport work. The chairman of the working group and the referee in the DTU workshop (which both are actively involved in the work in IMO on this matter) gave an introduction to this index.

When this index is introduced – hopefully within the next 2 – 3 years it will have two consequences, namely that the average speed of ships in the future will decrease and secondly that new and more efficient powering methods of ships are introduced, i.e. more efficient engines, better propellers, hull forms with less resistance etc.

In fig. 1 is shown the consequence on the Energy Efficiency Design Index by reducing the speed with 10 and 20% respectively for container ships within the whole range of deadweight (weight of cargo, oil, ballast water and consumables) of this ship type (100 – 15000 containers).

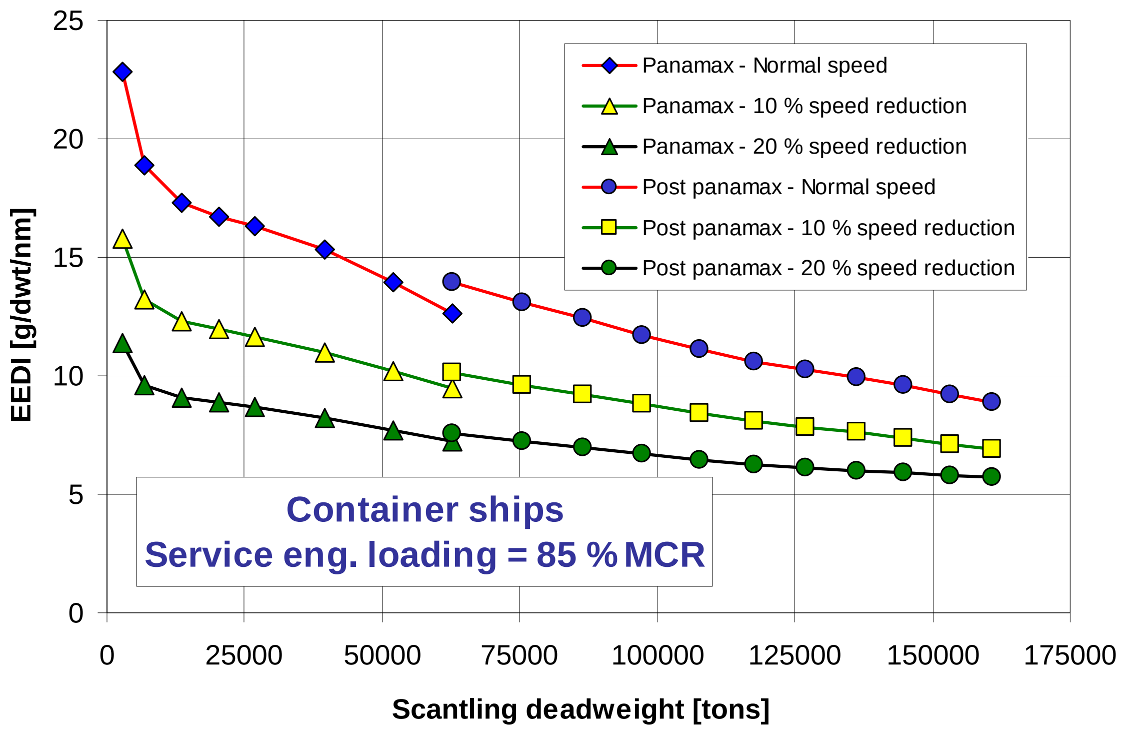

Fig. 1 **Influence of ship speed and deadweight on the Energy Efficiency Design Index (‘CO_2’ index expressed as emitted gram CO_2 per ton deadweight per nautical mile for container ships.**

Possible CO_2 reductions

Among the participants in the group discussion (which included representatives from ship owners and operators) there were a general acceptance that the efficiency of ships could be increased quite a lot by following three different pathways:

1. Introduction of operational measures, which include slow steaming, awareness of energy efficient operation (decision support systems for the crew), route planning including logistic planning. CO_2 reduction potential: 10 – 15%
2. Technical measures, which include better propellers, hull forms with less resistance, new hull painting types, introduction of wind powering, utilization of solar energy (not yet very proven), improved diesel engine technology. CO_2 reduction potential: 10 – 15%
3. Market based measures. The two market based measures discussed in IMO in order to reduce CO_2 are a global Emission Trading Scheme (ETS) and an International Fund for Greenhouse Gas Emissions from Ships (International GHG Fund). The proposal on an International GHG Fund implies that the revenue

from a bunker fuel contribution is allocated to an International GHG Fund in order to finance climate projects in developing countries as well as technical cooperation and research among other things. CO_2 reduction potential: 10 – 15%

It is thus evaluated that an efficiency increase of 30 – 45% (the lowest value for existing ships and the highest value for new ships) seems possible in a short term perspective up to 2020. On a longer term basis up to 2050 more improvements will most probably be possible, but the measures to achieve this does not seem clear today.

Nuclear power for ship propulsion

There was a clear consensus that nuclear powered merchant ships were not an alternative to reduce the CO_2 emissions from fossil fuels, although the first cargo ship ,Savannah, was launched 50 years ago (21st July 1959). This ship was one of only 3 nuclear power merchant ships in history. The arguments for not being able to use nuclear power for merchant ship propulsion are more political orientated than pure technical:

1. Health issues (probably extensive training of crew, lack of general acceptance from the public community)
2. Security issues (e.g., risk of terror attacks)
3. Safety issues (e.g., risk of collisions and groundings and risk of loss in a harsh environment)

Last but not least the use of nuclear power will probably not be economically competitive with the current bunker prices and not even higher prices in the future. The conclusion is therefore that nuclear power is not an alternative to fossil fuels for powering of ships.

Slow steaming (reduced ship speed)

The issue of slow steaming to reduce CO_2 emissions was discussed and there was a general acceptance that this measure is efficient, but in some cases the delivery time is important, so the answer depends on the cargo category. However it is clear that the decision process has to be transparent. More information from the ship owners to the public is necessary, such that the end users, i.e. the costumers have full knowledge about the consequences of the selection of a short delivery time that requires high speed which results in high CO_2 emissions. A paradigm shift is ahead of us. Seen in the light of the present economic crisis slow steaming is obvious when there is an overcapacity of ships (as today).

Renewable energy for ship propulsion

Wind, sun, and perhaps wave power are evaluated as some of the renewable energy sources which might be used for ships in the future. Wind is already used (and has been used for hundreds even thousands of years in shipping!) However wind energy is only a supplementary energy source. A German company (SkySail) claims that in the best case their sail (a kite fixed to the ship) can reduce the power consumption by up to 20%. Wallenius Marine has made a study showing 10 – 15% possible additional power in the best case, depending on the technical configuration. Solar cells are also a possibility which will be tested by Wallenius Marine in the coming years. The possibility of using wave energy for ship propulsion will also be studied in the future by Wallenius Marine.

Use of electricity generated by a sustainable method (e.g., wind) was discussed and the possibility is already used sporadically when a ship is in harbor. In some harbors it is not allowed to generate electric power by the ships own auxiliary power system and in such cases the power source will be a stationary shore based supply (cold ironing). However when the ship sails a lot of energy is needed and today there is a clear technical lack of storage possibility onboard for electric power. Whether sufficient storage possibilities will be possible in the future is questionable. In this connection it shall be mentioned that the speaker from MAN Diesel pointed out that his expectations are that the diesel engine will still play a very important role as prime mover in ship propulsion in the future, however with steadily better performance with respect to the different exhaust gas emissions among which CO_2 is one of these.

Conclusion

Among the participants of the group discussion it was quite clear that there are several possibilities for reduction of CO_2 emissions from ships. It was also clear that many of these possibilities need to be introduced by more awareness of both the operators of the ships but also by the clients which have to specify and ask for more sustainable transportation; this will have a feed back to the shipping industry which will have to do their utmost to reduce the CO_2 emissions in the coming years – because:

ACTION IS NEEDED NOW!

Report from working group 2: Passenger air transport and its competitors

Chair: Jan Närlinge

Referee: Leif Sønderberg Petersen, Senior Advisor, Risø DTU

Question 1: How much can we further increase the efficiency of planes?

Planes have become 70% more efficient during the last 40 years, but we are not near the theoretical limit. Current engines are approx. 60% efficient compared to the theoretically perfect combustion. Materials could be improved and be lighter and stronger. Aerodynamic improvements could make wings more efficient and reduce the drag. Hydraulics could be replaced by electric devices. All of this demands research and development, which means that the industry must be able to finance. Energy harvesting technologies like piezoelectric, thermoelectric and solar could be applied to a much higher extent. Fuel cells could produce the electricity needed on board.

It is necessary to find efficient ways of collaborating with focus on specific technologies and exploring knowledge in “white space”: Industry, Universities and Technology Research Institutes. Furthermore, it is important to bridge between competitors.

Question 2: Lower flight speed is an efficient measure to reduce CO_2 emissions from aviation. Are we willing to accept the corresponding longer travel times?

Only the public can answer this – it is behavioral. Under many circumstances speed is an important parameter. Furthermore, flying at significantly lower speeds implies optimizing designs and air traffic management (ATM) around that, otherwise there would be no real savings. Such a paradigm shift is certainly not trivial, nor is it a quick fix, it is worth exploring, however.

Question 3: Which kind of renewable energy is possible for aviation in the future?

Just 55 weeks ago the very first flight of a commercial jet aircraft using sustainable (non-food, non agriculture competing, non deforestation driving) biofuel took place. Over the last two years, considerable testing have been conducted on four different engine types, including flight trials using four different types of biomass feedstock. Technical performance is met with sustainable biofuels. This new and clean renewable fuel source offers a much lower CO_2 lifecycle for air transport. The CO_2 lifecycle for these biofuels is expected to be at least 50% lower as compared to petroleum sources. Full approval could happen by the end of next year (2010) and the first commercial availability could begin within 3 to 5 years, with capacity increasing beyond that. Biofuels could be grown in areas not suited for food crops and irrigated with waste water.

Types of alternative fuels:

- Synthetic fuels like gas, coal or other hydrocarbon resources
- Other fuels like ethanol, methane, liquid hydrogen
- Biofuels like soy beans, algae, jatropha, halophytes and camelina

Biofuels are more rational to introduce in air transport since the number of fuelling stations (few hundreds) and vehicles (20.000) is very limited compared to the number of road transport fuelling stations (many thousands) and vehicles (hundreds of millions).

One size does not fit all but it has to be “drop in” – it is important to develop a viable alternative to fossil fuel within the biofuel domain.

In the long term many possibilities are being researched, e.g., fuel cells, hydrogen as well as different kinds of solar energy.

There is a great potential for global scale implementation.

Question 4: What is the reduction potential in optimizing the overall air traffic management (ATM) and flight control system?

ATM is the first step against reduced CO_2 emissions, followed by next generation planes, the ACARE goals for 2020, and finally alternative fuels.

The IPCC studies showed that improvements of 2 to 18% are possible of which 6-12% is ATM related.

This means a reduction of CO_2 emissions of 2 to 18% obtained through flight planning, optimized routing, optimized flight path and green approaches. Circling an airport waiting for permission to land is wasteful and not helping anyone.

Remove airspace restriction to allow single sky and direct routes.

In a well planned green approach the engines can be set on idle speed 42 minutes before landing, but it requires an advanced ATM to control the plane.

Question 5: What policy instruments are suitable for reducing greenhouse gas emissions from aviation? - standards, regulations, taxes, grants…….

The industry has made remarkable progress with only market forces. No other sector has a track record of fuel efficiency improvement as strong as that of aviation.

ICAO is considering potential global policy instruments/measures, recommendations are expected later this year.

A policy to reduce emissions should include technology/standards, operational and market based measures, and alternative fuels. A global fuel efficiency standard for new commercial airplane designs will help drive technological innovation in airframes and engines that improve aircraft fuel efficiency as well as environmental performance.

ETS is an economically efficient and environmentally effective mechanism for reducing CO_2 and reaching political and environmental goals if implemented intelligently. It must be global, not regional, and the revenue should be routed back to develop technologies making the sector more environment efficient. ETS could allow operators and sectors to control their growth by buying permits in a cost-effective way from industries or sectors that are able to reduce. ETS is the main tool of the Kyoto mechanisms. ETS is in line with the Polluter Pays Principle.

Several airline companies have initiated a CO_2 offset programme, where customers buy CO_2 reduction equaling the emission caused by the flight.

Question 6: Are there realistic alternatives to passenger air transport?
It is difficult to find realistic alternatives for global air transportation on the longer distances. Air transportation is time saving, safe and reliable. Sea transportation is not an alternative, unless it is for leisure. If we want to connect with people and nations around the world, air transportation is the fastest and most convenient travel mode. We should be working together to make a better future including sustainability and that means making the investment in technology and leveraging the innovative ideas of talented people around the world.

Short haul (travel time less than 800 kilometers/3 hrs) can in some cases be delivered more efficient with other means of transport like high speed trains, and it is important to utilize the complimentary effects of different means of transport.

The cooperation between train and plane could be more efficient by common check-in systems etc.

Other key issues discussed were:
Aviation accounts for 2% of total CO_2 emissions today, it could grow to 3% by 2050 (IPCC).

There is a need for global consensus and global goals if the CO_2 emissions from passenger air transport should be reduced.

Alternative fuels are not the only solutions, but a part of a comprehensive packet including technology, operation and market based measures.

Aviation can and should be the “first mover” at a global scale for alternative fuels because of its pioneering technological innovations.

The challenge of aviation is to show that its benefits to society outweigh its environmental costs.

Report from working group 3: Private car transport

Chair: Niels Buus Kristensen, Director, DTU Transport, Denmark

Referee: Allan Schrøder Pedersen, Head of Programme, Risø DTU, Denmark

Approx. 50 participants from the Climate Workshop on Transport attended the working group on private car transport, which was prefaced by three technical background presentations:

- Integration of electrical vehicles in the energy system
- Long-term perspectives for electrical vehicles
- Perspectives for Ecocars – is 100 kilometres per litre possible?

A fundamental question, which was raised during the group work, was: *What are actually the drivers for the widespread wish to introduce new technologies for traction of private cars?*

A dominant answer to this question certainly was, that fear for the consequences of climate change is a very important driver. Climate change is a global challenge and in the industrialised countries about 25% - in some cases even higher – of the CO_2 emissions originates from transport and private car transport accounts for a significant share. Thus, in our efforts to reduce emissions we will inevitably have to cut the use of fossil fuels in private cars. On the other hand, many participants were convinced that the demand for private car transport will not decrease in the future – but rather rise steeply, in the light of increasing welfare, especially in the major fast growing countries in Asia and – potentially - in Africa. Hence, given the need for CO_2 reductions the only solution that can accommodate the projected future car transport demand appears to be new technologies for traction which can efficiently utilize non-fossil fuels. However, with a view to the question raised above, the technologies must be viable and affordable also in the developing countries if we shall reduce global CO_2 emissions.

Other answers to the above question about drivers were stated. One was self sufficiency in the light of perspectives of increasingly scarce oil supplies and the related volatile oil prices. Many countries, including many EU countries and USA, with no or few domestic fossil oil resources, feel a strong need to minimise their vulnerability to import of such sources for economic as well as for geopolitical reasons.

Yet another answer to the question was a wish to introduce flexibility in the future sustainable energy system, which is likely to rely strongly on supply of electricity from wind and solar sources. Because of the intermittent nature of these sources the future energy system will need to balance capacity in periods where supply exceeds demand and in such periods the excess energy could at little or no marginal costs be used to produce fuel for private cars, at the same time reducing emissions from the cars.

Having identified a clear need to find and introduce new technologies for cars, the discussion aimed at identifying what such technologies might be and electrical vehicles based on batteries were immediately mentioned as a solution. Electrical vehicles do not emit pollutants in the transport phase and if the electricity originates from sustainable sources, battery cars can be very environmentally friendly. Furthermore electrical vehicles are highly energy efficient. It was argued that because of limited availability of renewable sources we have to prioritize energy efficiency and therefore many participants advocated for a quick introduction of battery cars in countries like Denmark, where a high share of sustainable electricity production is found.

However - somewhat in opposition to this viewpoint - it was argued, that electrical vehicles have a short driving range compared to what car owners are used to now and in addition, a long recharging time is a serious drawback for such vehicles. It was also acknowledged, that consumers are generally willing to pay for comfort, convenience and safety and, therefore, less efficient technologies, which may better meet demand for comfort and convenience, should not be ignored at this stage.

There was a general consent that it is not yet possible to pick a "winning technology" for the future private cars. Actually it was considered likely that combinations of technologies, such as batteries and hydrogen/fuel cells, may better meet the consumers´ needs than the single technologies themselves. Furthermore, it was believed that different technologies might well be used in parallel in different application areas.

Diversity of fuel supply was discussed in the working group. Diversity of supply was definitely considered very important to avoid strong economic and technical monopolies. Also, it was considered as a stabilizing factor if several sources might contribute to fuel production so that vital activities would not necessarily be hampered by break-down of one supply chain. As an example liquid fuels were mentioned. Such fuels may be produced from biomass and via electrolysis based on electricity from wind or solar power.

A number of other issues were raised. Although many of these issues were considered important, they were not discussed in details – mainly for time reasons. Examples are:

- How should or could taxes be used to control private car transportation? Many participants had a fear that sole economic costs would not within a foreseeable future motivate a technology transition. Taxes/tax exemptions might assist in this respect.
- Do we know that battery electrical vehicles are indeed basically a long term sustainable solution? Are electrical vehicles able to fulfill our needs for transport? Will we be satisfied with shorter action radii and lesser comfort than we are accustomed to?
- Early buyers of new transport technologies should be economically secured against the risk of lack of viability of the new technology. If we want ordinary consumers to take part in early deployment initiatives, we must ensure that they will able to exit without considerable economic losses in case of failure for the new technology.
- Demonstration projects are instrumental. There is little doubt that demonstration projects have great value in terms of marketing and technology development as well as public awareness and acceptance.
- Dual mode systems – rails and roads. Dual mode systems have a group of dedicated advocators. Some of the systems, like the RUF system, certainly have attractive features, but do they also possess the required flexibility to find use in our future private car transport at affordable infrastructure and vehicle costs?

Report from working group 4: Road based freight transport and its competitors

Chair: Michael Svane, Director, Confederation of Danish Industry, Denmark

Referee: Ole Kveiborg, Senior Researcher, DTU Transport, Denmark

Freight transport is dominated by two modes: sea transport and road transport. Sea transport is the main freight transport mode in overseas transport and road transport is dominant in domestic and intra-European transport. Moreover, sea transport and rail transport are in most cases associated with road transport both from the original shipping point and to the final destination.

The three freight transport arenas

Freight transport is operating in three different networks that are distinctive in the need for freight transport:

1. Freight transport in urban areas (within cities)
2. Interurban freight transport (between cities and regions)
3. Global transport (between continents)

Road freight transport is primarily working in the first two arenas, which are both linked to the global transportation network. It is vital to distinguish between the three networks in the discussion of CO_2 reductions in the road freight sector and potential solutions to reduce emissions must not be discarded because they cannot be applied for all three networks.

Transport in urban areas, and to a large extent also in the interurban network, is mainly delivered by trucks. The focus in the short to medium term will thus be on reducing the CO_2 impacts from road transport in these two arenas.

Propulsion systems today and in the future

There are a number of different alternative fuels that can be and are already considered in both the road freight transport sector as well as in passenger transport. However, most of these alternatives have significant deficiencies as potential alternatives to the diesel engine. The *diesel engine* has until this day, been the most efficient propulsion system for road freight transport due to the many constraints coming from inside the sector as well as the exterior constraints. There are at present no indications that this is likely to change in the coming years.

Gas is an alternative fuel with some potential in urban and to some extent interurban freight transport. Vehicles using gas and gas engine technologies already exist and many diesel engines can be adjusted to use gas. The supply infrastructure required for gas driven trucks is to some extent already in place in many Central- and East-European countries. This infrastructure is simpler to set up compared to the need for passenger cars, since trucks have a much longer operating radius and refuelling is planned ahead at very specific locations. So the need for many refuelling points is smaller compared to the needs of passenger cars. Furthermore, there are several examples where gas driven vehicles are used.

Several urban bus companies use gas driven busses. It is relatively easy to design the refuelling infrastructure for urban bus operation, since it can be done at the garages, where bus companies keep their busses. Moreover, adaptations of busses to urban distribution vehicles are well advanced by e.g. Scania trucks. Gas driven trucks thus seem a likely alternative to diesel driven trucks in urban areas and possible also in interurban transport in the future.

Electric driven trucks are with the present battery technology not an option for large trucks, but may have a potential in urban distribution with small vans. If the energy for an average truck used for interregional transport should be based on batteries, then these batteries would consume (almost) the entire payload capacity of such trucks. The result would be a very large increase in the number of vehicle kilometres by trucks and a heavy increase in congestion on the European roads.

The motor technologies are improving all the time such that not only fuel efficiency is increased, but the vehicles can now be constructed such that they are rather flexible with respect to the use of different fuel types. However, diesel engines remain the central element in these hybrid and flexible vehicles.

It makes sense to increase the allocation of different fuels to different uses, due to the limitations in the use of alternative fuels for heavy vehicles. As the potential for electric vehicles seems so much larger for passenger cars and small distribution vans, then this is where focus should be addressed. Batteries or fuel cells in heavy vehicles are both technologies that must wait until the systems are developed and the capacity of batteries is much higher.

What can be done in the short run?

There are several things that can improve fuel efficiency also in the road freight sector. Training drivers in energy-efficient driving techniques, allowing larger vehicles, and reducing average driving speed are three initiatives, that all have interesting energy saving potential, but especially the latter have some implications that must be considered. Lower speed is not a large problem in relation to the shippers of goods, who simply have to add the extra transport time to their lead time and perhaps also look at a slight increase in costs (which can be passed on to the consumer). Lower speed is, however, a safety problem on especially motorways where large speed differences between different (types) of vehicles increase hazardous driving and thereby increase the risk of accidents.

Another potential in the short run is a further use of taxes and charges. This is an instrument that will increase focus on delivering better and smarter transport solutions with lower energy consumption etc. But increasing e.g. kilometre charges for trucks will in the end lead to higher prices on consumer goods with a decrease in overall demand as the outcome. Road user charges are very likely to come in many European countries in the coming years. Not only due to the potential as a means of reducing CO_2 emissions, but also due to their potential as a traffic management scheme for reducing congestion and local detrimental effects of transport. This may raise another problem, which is also present for some technological improvements aimed at reducing energy consumption and other emissions, since such objectives may be work against each other. Technologies aimed at reducing NO_X and PM emissions may increase energy consumption. The balance between different objectives thus has to be present in the decisions made on reducing the emission of climate gasses from freight transport.

There are also un-invented and un-used technological innovations that may largely improve the freight transport sector’s energy efficiency. However, current regulation and the differences between regulations across European countries are barriers for individual companies to change current behaviour and focus on new ways of delivering transport solutions. This is in particular a problem in the rail freight sector where regulations differ significantly between different countries and where the prioritization of passenger transport are important barriers for increased rail transport in freight transport.

The potential for rail freight transport must be seen in a larger perspective, though. It is not possible to expand the rail network to the same extent as the road network. Hence, rail transport will always be accompanied with road transport. Moreover, there are already today significant bottlenecks in certain locations on the rail infrastructure (e.g., in and around Hamburg). Analyses have shown that even a doubling of the European rail infrastructure may only lead to a 7% reduction in road freight transport.

Future challenges in the transport sector

by Jørgen Henningsen, former Principal Advisor, European Commission, DG Energy and Transport

The EU targets are set to limit the temperature rise to 2 degrees C. But can we be sure that the strategies in Brussels will meet this limit? The 4th assessment report from IPCC is already 2 years old and based on preceding science, so we are already behind.

We must achieve 50% reduction globally in 2050. If this should be possible, industrialized countries must do more. 75% is not too much.

Actually there is great potential to reduce CO_2 emissions and save money, so a 3.5% annually reduction is easy today. This is equivalent to 30% per decade, which immediately seems to fit with EUs strategies. But the 20% are over 3 decades, not 1 decade, which means that EU now is 8% behind; this is partly due to the EU enlargement. Most of the 20% can be dealt with through CDM and similar mechanisms. The 20% were decided on the last day of Poznan, but it is in reality only a 5% reduction as a result of the above. EU will not put pressure to impose tougher targets COP15. The extra 10% that could come as a new requirement could be reached by further exploitation of CDM etc. We can expect a 10% reduction in this decade.

Coal, oil and gas will decline more than is needed. My conclusion is that the world would be better helped by making an agreement to deliver what is needed.

This is especially important for the transport sector, because it is an international activity. It is important because transport moves people and goods between countries, and we must all have the same transport system. The same suppliers supply the entire world. We can not discuss the importance of regional planning.

How do we make a transport sector with much less CO_2 emissions?

With regard to security of supply EU focuses solely on gas security, and there is a distinctive challenge for gas. But the biggest problem is oil, especially for Europe and not at least for Denmark when the Danish resources are depleted within a short range of years. The latest message from Fatih Birol, IEA, is that the world is running low on oil.

EU is perfectly situated for gas supply, surrounded by countries with large gas resources. Actually 80% of world gas resources are lying around EU. The so-called gas crisis between Russia only meant a small drain on EU's stock, so we have no gas crisis.

Transport is entirely dependent on oil and there is a long way to renewable energy in transportation, therefore gas is the best alternative to gasoline.

The counterargument is that it causes supply problems, but two resources will actually enhance the security of supply.

Shift from diesel to gas in transport of goods would save 20% CO_2, and biofuel would be expensive. But unfortunately questions about security of supply are blocking the use of gas.

In the medium term we can shift from oil to natural gas in the diesel sector, but not in the petrol sector.

We have seen a big shift from gasoline to diesel and we are exporting more and more gasoline to the U.S. where the situation is inverted. We need the same volume of crude oil because we use so much diesel, and it increases the security of supply in the U.S.

It is easy to build a gas infrastructure for trucks because they have rather few fuelling points compared to private cars.

In the long term it is important to find ways to run the society on electricity.

A picture emerges where electricity plays a bigger role and there is a coherent EU strategy for electricity in cars and hybrid cars. Moreover, efficiency improvements in transport should be utilized much better than today. It seems as if efficiency improvements apply only to private cars, but there is a huge potential in other sectors too, such as simply lowering the speed with 10% will save 19% fuel, and then we can get all the anchored ships in operation again. IMO must engage in this. The same applies to planes; if the speed was lowered from 850 KMT to 750 KMT it would save lots of fuel.

There is no panacea in the transport, but many different approaches can lower the CO_2 emissions and get the whole sector to think differently, including the question of the role of oil.

The commission has not succeeded in coordination of transportation policies, and transportation is now more or less placed between two chairs in the EU. An integrated climate policy, energy policy and transport policy is missing.

Panel discussion

Transportation is a matter of both security and climate and it will become more visible. Measures in transport are more expensive than in other sectors and more difficult to achieve. Overall, transport may provide less input to CO_2 reductions than other sectors.

The workshop has resulted in plenty of ideas for efficiency improvements in the transport sector. There were a lot of ideas of how to pick the low hanging fruit and the fruits already lying at our feet. These must be picked up as soon as possible. But who is lobbying for efficiency? It is important that it is customers who want to procure and their focus is primarily on fuel economy. It is necessary to maintain pressure on the technologies, which require standards. New long term standards are important to affect which cars people actually will buy and on the other hand to give the manufacturers time for planning the production of new cars. Taxes may intensify the impact of standards along with pricing that links to CO_2 elements.

It is worth to remember that when it was decided to introduce catalytic converters the consumers was not asked, and the manufacturers advised against it because they felt that people could not afford pay the extra money for the car. Likewise one should not ask the public whether it accepts longer flight times, but just decide to do it through the appropriate regulation.

With regard to the security issue it is important to focus on a wide range of fuels and technologies, including gas as a supplement or replacement for oil.

In Denmark the energy efficiency statistics do not include transportation, since the transport sector unfortunately is not considered a part of the energy system.

It is a good idea to turn Denmark into a green test bed because Denmark has a good international record and a strong branding.

Programme

17 March 2009

09:00 – 09:30	**Registration and coffee** Entrance to Auditorium 54, building 208, DTU Lyngby Campus
09:30 – 10:05	**Welcome and OPENING SPEECH** Auditorium 54
09:30 - 09:35	**Welcome** Niels Axel Nielsen, Director, Public Sector Consultancy, Technical University of Denmark
09:35 - 10:05	**OPENING SPEECH** Lars Barfoed, Minister for Transport, Denmark
10:05 – 10:30	**Presentation of discussion paper for the workshop** Niels Buus Kristensen, Director, DTU Transport, Denmark
10:30 – 10:45	Coffee break
10:45 – 12:15	**Keynote speeches** **The future for the transport sector – Energy technology perspectives** Pieter Boot, Director, Directorate of Sustainable Energy Policy and Technology, IEA
	The economical perspectives by Philippe Crist, Joint Transport Research Centre of the OECD and the International Transport Forum, France
	Renewable energy for transport by Robert Schock, World Energy Council, UK
12:15 – 13:15	**Lunch**
13:15 – 15:15	**Keynote presentations as introduction to the working groups**
	Technology innovation for environmental shipping Bo Cerup Simonsen, Vice President, A.P. Moeller - Maersk, Denmark
	International passenger air transport Jan Närlinge, President, Boeing Northern Europe, Vice President, Boeing International
	Passenger transport in private cars on short and medium distances Nils-Olof Nylund, Professor, VTT Technical Research Centre of Finland
	Transport, climate and energy perspectives Martin Lidegaard, Chairman, Concito
15:15 – 15:45	Coffee break
15:45 – 18:00	Participants are divided in four working groups on the following four subjects:
	International sea transport Group room 168, building 210 *Supplemental remarks*, by Bo Cerup Simonsen *Wallenius' long term strategy on climate and environment*, by Per Croner, President for Wallenius Marine, Sweden *Future potential for prime movers of large ocean going ships*, by Niels Kjemtrup, Senior Manager, Process Development, MAN Diesel, Denmark *Summary of background paper for the workshop*, by Hans Otto Kristensen, DTU Mechanical Engineering, Denmark *Chair: Christian Breinholt, Director, Danish Maritime Authority, Denmark* *Referee: Hans Otto Kristensen, Senior Scientist, DTU Mechanical Engineering*

	Passenger air transport and its competitors Group room 162, building 210 *Supplemental remarks*, by Jan Närlinge, President, Boeing Northern Europe, Vice President, Boeing International *SAS' involvement in reducing the environmental impact of its air transport activities*, by Martin Porsgaard, Director, Environment and Sustainability, SAS Group *ICAO's work on aviation emissions*, by Jane Hupe, Chief, Environmental Unit, ICAO, Canada *High speed trains versus short-haul aviation routes*, by Gunnar Sibbmark, 1st Vice Chairman and MD, Europakorridoren AB *Chair: Jan Närlinge* *Referee: Leif Sønderberg Petersen, Senior Advisor, Risø DTU*
	Private car transport Group room 142, building 210 *Supplemental remarks*, by Professor Nils-Olof Nylund *Integration of electric vehicles in the energy system*, by Esben Larsen, Lektor, DTU Electrical Engineering *Long-term perspectives for electric vehicles*, by Martine A. Uyterlinde, Manager, Energy in Transport and Buildings, Energy Research Centre of the Netherlands (ECN) *Perspectives for Ecocars – is 100 kilometers per litre possible?* by Jesper Schramm, DTU Mechanical Engineering, Denmark *Chair: Niels Buus Kristensen, Director, DTU Transport, Denmark* *Referee: Allan Schrøder Pedersen, Head of Programme, Risø DTU, Denmark*
	Road based freight transport and its competitors Group room 148, building 210 *Supplemental remarks*, by Martin Lidegaard, Chairman, Concito *Sustainable freight transport*, by Jens Hügel, IRU, the International Road Transport Union *Business case no 1: PostDanmark*, by Søren Boas, Head of Environmental Affairs *Business case no 2: Schenker Rail*, by Stig Kyster-Hansen, Managing Director, Schenker Rail *How to act as a car manufacturer*, by Mikael Friis, Information Manager, Scania Denmark *Chair: Michael Svane, Director, Confederation of Danish Industry, Denmark* *Referee: Ole Kveiborg, Senior Researcher, DTU Transport, Denmark*
18:00 – 18:45	**Reception before dinner. Auditorium 54, building 208**
19:00 – 21:00	**Dinner , Faculty Club, building 101**

18 March 2009

08:30 – 09:15	**Coffee. Entrance to Auditorium 54**
09:15 – 10:00	**Welcome** by Niels Axel Nielsen
	Future challenges in the transport sector by Jørgen Henningsen, former Principal Advisor, European Commission, DG Energy and Transport. Auditorium 54
10:00 -11:00	**Workshops wrap up**
11:00 – 13:00	**Panel discussion. Presentation of main conclusions from the four working groups** Moderator: Hans Larsen In the panel: Pieter Boot, Director, Directorate of Sustainable Energy Policy and Technology, IEA Philippe Crist, Joint Transport Research Centre of the OECD and the International Transport Forum, France Jørgen Henningsen, former Principal Advisor, European Commission, DG Energy and Transport Christian Breinholt, Director, Danish Maritime Authority, Denmark Jan Närlinge, President, Boeing Northern Europe, Vice President, Boeing International Niels Buus Kristensen, Director, DTU Transport, Denmark Michael Svane, Director, Confederation of Danish Industry, Denmark
13:00 – 14:30	**Lunch**

List of participants

First name	Surname	Company
Anders	Abrecht	Samvirke
Lars Skovgaard	Andersen	Danske Capital
Robert	Arendal	Goodwill Ambassador
Sabrina	AZAIEZ	
Olexandr	Balyk	Risø DTU
Christian	Bang-Møller	DTU MEK
Anne Sofie	Bender	Nordic Council of Ministers
Lisa	Bjergbakke	Danish Energy Agency
Karine	Blandel	French Embassy
Søren	Boas	Environmental Affairs
Pieter	Boot	IEA
Jan	Boyesen	Øresund Logistics
Christian	Breinholt	Danish Maritime Authority
Noel	Brings Jacobsen	Region Sjaelland
Poul	Bruun	ITD - International Transport Danmark
Niels E.	Busch	Busch & Partners
Linda	Christensen	DTU Transport
Henning	Christiansen	Road Safety and Transport Agency
Ole Balslev	Clausen	Ingeniørforeningen i Danmark
Philippe	Crist	Joint Transport Research Centre of the OECD
Per	Croner	Wallenius Marine
Thorfinn	Deleuran	Danish Energy Agency
Subash	Dhar	UNEP Risø Centre
Lars	Dithmer	Project ByPass
Claus	Ekman	Risø DTU
Loren	Everly	Lund University
Rebekka	Falk	Danish Energy Agency (Energistyrelsen)
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Lærke	Flader	Dansk Energi
Anders Holm	Foosnæs	Dansk Energi
Michael	Fowler	elbil network
Marianne	Frank	International Transport Danmark (ITD)
Niels	Frees	Road Safety and Transport Agency
Mikael	Friis	Scania Denmark
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Iben	Frøkjær Strand	DTU - Myndighedsbetjening
Oliver	Gehrke	Risø DTU, Wind Energy Division
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		operations management
Danny	Gold	DTU
Ezra	Goldman	Morfeme
KANNAN	GOVINDAN	University of Southern Denmark
Bo	Gregersen	US Embassy Copenhagen
Julien	Grunfelder	Skov & Landskab, Life Faculty, KU
Henning	Gudmand-Høyer	Dansk Standard
Jayantha	Gunathilake	Ministry Of Transport
Julien	Gutknecht	E.ON Sverige
Nikolay	Gutor	Embassy of the Russian Federation
Pernille	Hagedorn-Rasmussen	Ingeniørforeningen, IDA
Rolf	Hagman	Institute of Transport Economics
Erik	Hall	US Embassy Copenhagen
Kirsten	Halsnæs	Risø DTU
Nicoline	Haslev-Hansen	UNEP Risø Centre
Lars	Hasselager	Danish Energy Agency
Jacob	Heinsen	Transportministeriet
Martin	Hellung-Larsen	Road Safety and Transport Agency
Jørgen	Henningsen	
Frederik	Hoedeman	Public Transport Authority
Jane	Hupe	ICAO
Jens	Hügel	International Road Transport Union (IRU)
Palle	Jensen	RUF International
Thomas Christian	Jensen	DTU Transport
Lotte	Jensen-Holm	Topsoe Fuel Cell
Per Homann	Jespersen	Roskilde University
Jing	Jing	KTH - Royal Institute of Technology
Nick	Johansen	DTU Mechanical Engineering Wind Energy
Esperanza	Jurado	DTU
Finn	Jørgensen	Haldor Topsøe A/S
Frank Vernon	Jørgensen	JVL Industri Elektronik A/S
Ida Lunde	Jørgensen	Copenhagen Capacity
Fintan	Keenan	Copenhagen International School
Kim Strate	Kiegstad	Siemens A/S
Niels	Kjemtrup	MAN Diesel
Anders Helmuth	Knudsen	Danish Maritime Authority
Klavs	Koefoed	Ramboll
Thomas	Korbel	DTU
Hans Otto	Kristensen	DTU/MEK
Niels Buus	Kristensen	DTU Transport
Anne Louise	Kristiansen	Ministry Of Transport
Ole	Kveiborg	DTU Transport
Stig	Kyster-Hansen	Schenker Rail
Esben	Larsen	DTU.Elektro
Hans	Larsen	Risø DTU
Jeppe Mulvad	Larsen	DTU
Kjeld A.	Larsen	Rådet for Bæredygtig Trafik
Claus	Lewinsky	Danish Energy Agency

Martin	Lidegaard	Concito
Ulrich	Lopdrup	Road Safety and Transport Agency
Lasse Ernlund	Lorentzen	Innovative Reflections
Michael	Lund	BIMCO
Ahmed	Lüfti Øzer	Road Safety and Transport Agency
Frank	Marcher	Danish Commission on Climate Change Policy
Francesco	Marra	DTU - Elektro
Lorenzo	Martini	Embassy of the United States to Denmark
Thomas	Midtgaard	Danish Agency for Science, Technology and Innovation
Jacob	Mogensen	Center For Bioenergy og Miljøteknologisk Innovation (CBMI)
Björn	Mollstedt	E.ON Sverige
Tim	Mondorf	IBM
Vivi	Morsing	Risø DTU
Romain	Mouret	French Embassy
Edmond	Muller	DTU Elektro
Grit	Munk	Ingeniørforeningen i Danmark
Camilla	Mørk	Klima- og energiministeriet
Ivan	Nekrasov	DTU
Gert	Nielsen	Forvirk og SSV
John Koch	Nielsen	Transportens Innovationsnetværk / FORCE Technology
Lars Henrik	Nielsen	Risø DTU
Marianne	Nielsen	Energistyrelsen
Niels Axel	Nielsen	DTU - Myndighedsbetjening og Sektorudvikling
Niels-Anders	Nielsen	Road Safety and Transport Agency
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Uffe	Nielsen	Danish Regions
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Jan	Närlinge	Boeing Northern Europe
Steen	Nørby Nielsen	Siemens A/S, Mobility
Keld	Olsen	Råd. Ing. Keld E. Olsen
Mogens	Olsen	British Embassy Copenhagen
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Lars	Overgaard	Teknologisk Institut
Thomas	Overgaard Jensen	FRI: The Danish Association of Consulting Engineers
Allan Schrøder	Pedersen	Risø DTU
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Tommy von	Pein	21st-cc
Leif Sønderberg	Petersen	Risø DTU
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Martin	Porsgaard	SAS Group
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Norma Acosta	Romero	Embassy of Mexico
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Robert	Schock	World Energy Council
Manfred	Schou	Schou Consult
Jesper	Schramm	DTU - Dep. of Mechanical Engineering
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Flemming	Warth	Dansk El - Forbund
Mikkel	Westenholz	PA Consulting Group
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Can	Özenc	AIESEC UNIC

Risø DTU is the National Laboratory for Sustainable Energy. Our research focuses on development of energy technologies and systems with minimal effect on climate, and it contributes to innovation, education and policy. Risø has large experimental facilities and interdisciplinary research environments, and includes the national centre for nuclear technologies.

This report is part of a series of workshops and conferences arranged as a part of DTU Cimate Change Technology, a research programme run by the Technical University of Denmark.

DTU Climate Change Technologies aims to take scientific research, present it to key players in the fields of energy and climate changes to produce new technologies and processes. The goal is to reduce CO_2 emissions and support industrial production and welfare in adapting to climate change. Read more at dtu.dk/subsites/klima/English.aspx

Workshops

Sustainable Buildings - 19 June 2008
Future Energy Systems - 19 - 20 November 2008
Sustainable Energies - 14 - 15 January 2009
Animal Health and Food Safety - March 2009
Transport - renewable energy in the transport sector and planning - 17 - 18 March 2009
Climate Changes and Ecosystem Productivity - May 2009
Combustion, Carbon Capture and Storage - 27 - 28 May 2009
InfraStructure and Climate Changes - 1 September 2009

Research conferences

Changes of the Greenland Cryosphere - 25 - 28 August 2009
Risø International Energy Conference - 14 - 16 September 2009

Final round-up forum

High-level Conference - 17 September 2009

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